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THE NEUTRON SPECTROMETRY SYSTEM USING ^{3}He COUNTER

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Abstract

A spectrometry system was designed for neutron counting at the horizontal channels of Dalat nuclear reactor. The system is able to interface to PC via EZ-USB with full speed. The designed system can be installed for operation not only at the channel No. 4 of the reactor, but also operated with the neutron Howitzer system installed at the Training Center of Nuclear Research Institute for training purposes. Almost results can be achieved effectively while choosing the shaping time of 2 μs of amplifier unit; and an appropriate preamplifier is used to measure neutron spectra. In this work, the multi-channel spectrometer for measuring neutron was designed and tested.

1. Introduction

Neutrons have characteristics that make them of particular importance in research. Since neutrons are uncharged, they are able to enter the nucleus at very low energy. Furthermore, the lack of energy losses through ionization permits deep penetration into materials [4]. This latter characteristic makes detection of neutrons more complicated than detecting protons or alpha particles [9]. The energy of these charged particles can easily be determined by detecting them in proportional counters. Because neutron is a neutral particle, therefore, it has never been affected by the presence of electro-magnetic field. Thus, instead of attempting to see the neutron directly, the byproducts of neutron reactions

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or their collisions must be detected. The general idea in neutron detection is to convert the uncharged neutrons into charged particles, and thereby directly detectable ones [7]. One type of the proportional counters largely sensitive to thermal neutrons is $^{3}\mathbf{He}$ neutron counter.

2. Experimental

2.1 Brief review of ^{3}He counter

$^{3}\mathbf{He}$ proportional counters utilizing $^{3}\mathbf{He}$(n,p)$^{3}\mathbf{H}$ reaction for detection of thermal neutrons (E $\sim$ 0.025 eV) are showed on diagram as follows:

$$^{3}\mathbf{He} +^{1} n(thermal) \longrightarrow^{1} \mathbf{H} +^{3} \mathbf{H} + Q$$

where $Q = 764$ keV.

The energy of the reaction is carried away as kinetic energy of daughter products, which move in opposite directions. $^{3}\mathbf{He}$ neutron counter provides an output pulse which is proportional to 764 keV for thermal neutrons. Cross section follows a $1/v$ relationship (v = neutron velocity) up to about 0.2 MeV. Obviously, on the left of the full energy peak (refer to Fig. 3) there is a region known as the 'wall effect' which contains two discontinuous steps. The wall effect arises because proton and triton daughter products of the reaction have discrete energies (573 keV and 191 keV, respectively). When one of the daughter products collides with the wall of the detector, its energy is dissipated and does not contribute to the full energy peak, thus creating the discrete steps in the spectrum [5].

2.2 Pulse height distribution of ^{3}He counter

As known, neutrons are produced in nuclear reactors or in neutron generators. They are detected in presence of a level of gamma radiation background. When neutron energy of interest is in the thermal region, $^{3}\mathbf{He}$ proportional counter is used. This involves neutron detection indirectly by a nuclear reaction which generates a charge particle [3]. The experimental measurements were carried out in the horizontal channel No. 4 of Dalat nuclear reactor. The block diagram was shown in Fig. 1.

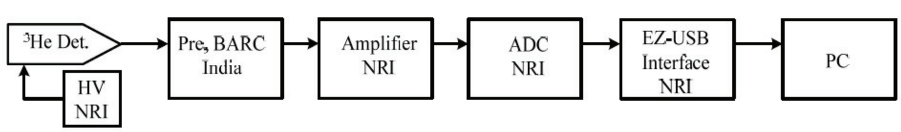

Fig. 1: Block diagram of MCA system for neutron detection.

In the system, the preamplifier was designed by BARC, India. All of other functional electronics modulars were fabricated by NRI-DaLat. The ^{3}**He** counter is a thermal neutron one, model RS-P4-0806-207, Reuter Stokes, GE Company. The counter will well operate with shaping time of the amplifier to be 2μs [8] and the positive bias supply to be about 1200 V (please refer to Fig. 2.).

Through the above arrangement, pulse height distribution was shown in Fig. 3.

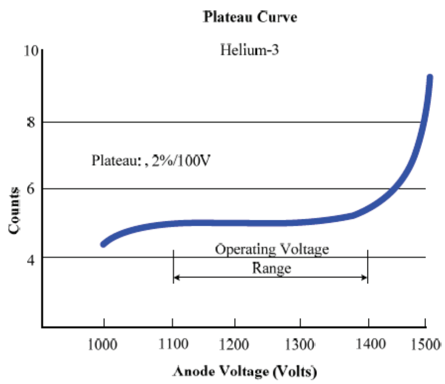

Fig. 2: Plateau of the counter.

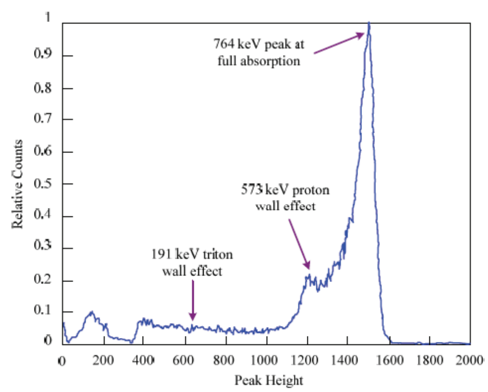

Fig. 3: Pulse height distribution of ^{3}He counter [6].

2.3 Operation of MCA

Signal output from the preamplier of Model 522B, BARC India was large enough for use in conjuntion with the proportional counter. This preamplifier provides the output which has the rise time about 25 ns for signal pulses, and the pulses would gain by the amplifier with the following suitable factors: shaping time of 2μs, coarse gain of 10, fine gain of 6.7. Next, the ADC unit acquired data at 2.2 μs, sample/hold rate at 400 kSPS [1]; then, EZ-USB interface unit processed the data output of the ADC under the control of firmware which developed by Ckeil-51 for AN 2131Q [2] owing to USB port at full speed. Eventually, the spectra were drawn in LabView language through a PC.

3. Results

Some results were obtained through the above mentioned arrangement. When the channel was closed, just only gamma noise appeared (refer to Fig. 4); in the contrary, neutron spectra was obtained obviously while the channel was opening. It was worth to point out that the experimental results were appropriate to the theory ones! The Fig. 5 presented the results as follows: the full peak of the reaction at energy of 764 keV, two others are at 191 keV and 573 keV due to wall effect and gamma noise.

Parameters related to the measurement were as follows: Lower level is at channel of 38, upper level is at channel of 8191, realtime is 1039 sec (including livetime and deadtime), the full peak of 764.248 keV at channel of 1983 having counting pulses of 643.

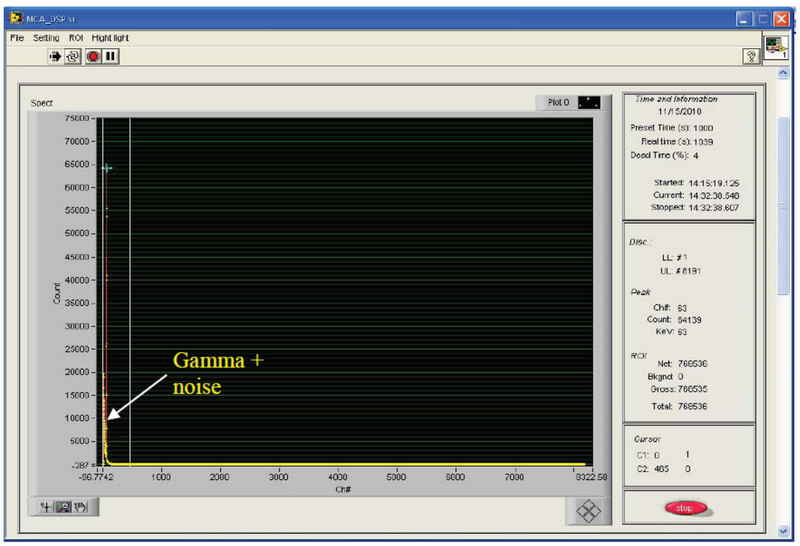

Fig. 4: Gamma + noise obtained in case of closed channel No. 4.

4. Conclusions

The system was constructed, and tested at the channel 4 in DaLat reactor. An application Software package developed in LabView with flexible options allowed users to get data from the devices and process them. Owing to interfacing to PC via EZ-USB controller (AN 2131Q) with the control of C-firmware, data from the system will be transferred to PC at fast enough speed (12 Mb/s) through USP port. It can be installed for operation not only at channel No. 4 of Dalat nuclear reactor, but also operated with the neutron Howitzer system at the Training Center of Nuclear Research Institute for training purposes.

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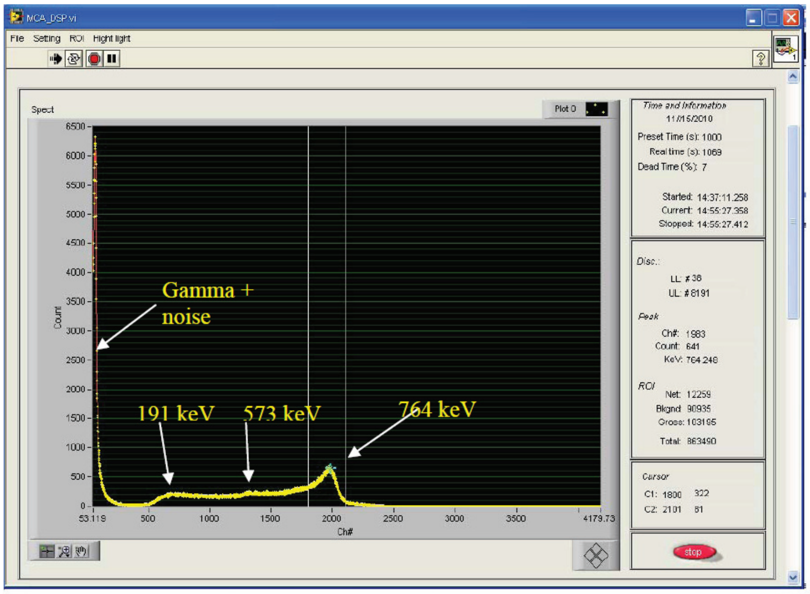

Fig. 5: Neutron spectra obtained in case of opened channel No. 4.

level within period of 2010-2011 on 'Study, designing and construction of experimental instrument system for measuring neutron characteristics and neutron activated analysis to serve for training activities of nuclear human resources'.

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